with help from Christina Mesropian

LHCP 2014

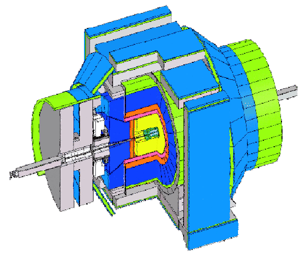
QCD at the Tevatron

Rick Field
University of Florida
(for the CDF & D0 Collaborations)

Quantum **C**hromo-**D**ynamics

Outline of Talk

- **D0 Photon + Jet Measurements.**
- **CDF W/Z + Upsilon Search.**
- **CDF Measurements of σ(V+D*)/σ(V).**
- **D0 Measurements of Z + c-jet.**
- **CDF "Tevatron Energy Scan": Findings & Surprises.**
- **D0 DPS in γ + 3 Jets and γ +b/c + 2 Jets.**
- **Summary & Conclusions.**



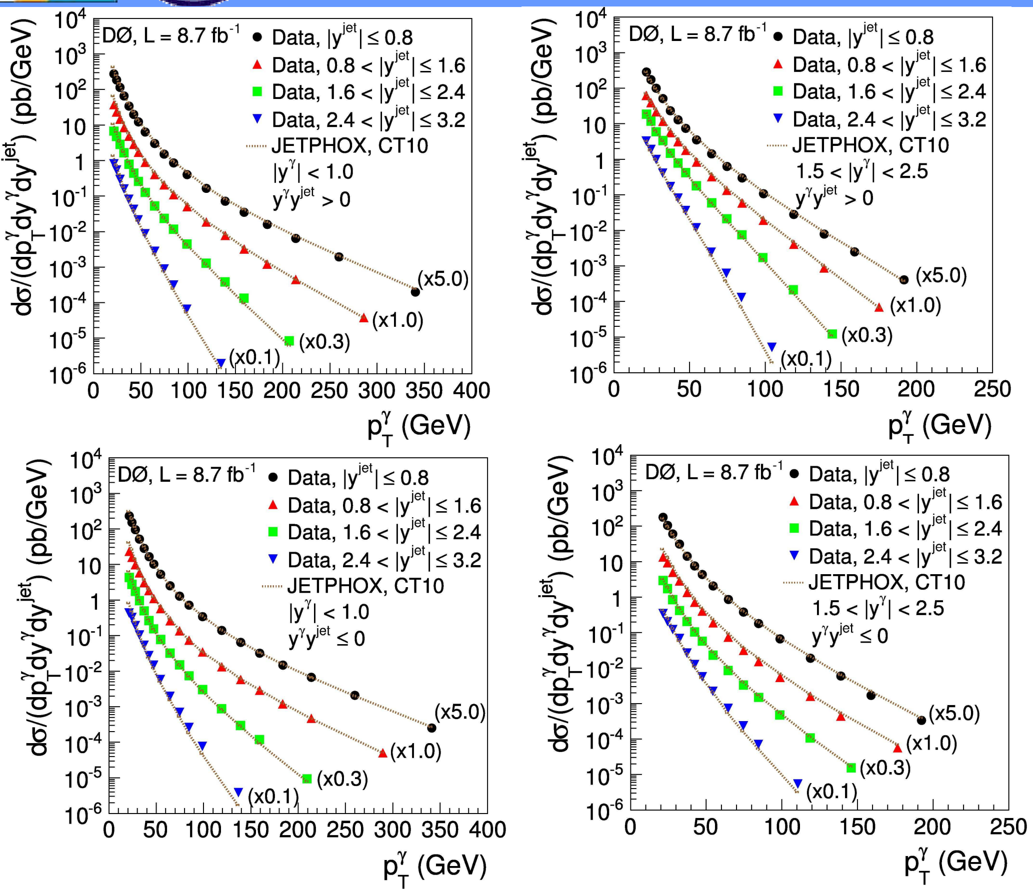
CDF Run 2
300 GeV, 900 GeV, 1.96 TeV

Photon + Jet Production

New since LHCP2013

Phys. Rev. D 88, 072008 (2013)

8.7 fb^{-1}



➡ **D0 differential γ + jet cross section as a function of $p_T(\gamma)$ for four jet rapidity intervals, with central photons, $|y| < 1.0$, and forward photons, $1.5<|y|<2.5$, for same-sign and opposite-sign of photon and jet rapidities. For presentation purposes, cross sections for $|y_{jet}| \le 0.8$, $0.8 < |y_{jet}| \le 1.6$, $1.6 < |y_{jet}| \le 2.4$ and $2.4 < |y_{jet}| \le 3.2$ are scaled by factors of 5, 1, 0.3 and 0.1, respectively. The data are compared to the NLO QCD predictions using the jetphox with the CT10 PDF set and $\mu_R = \mu_F = \mu_f = p_T(\gamma)$.**

Photon + Jet Production

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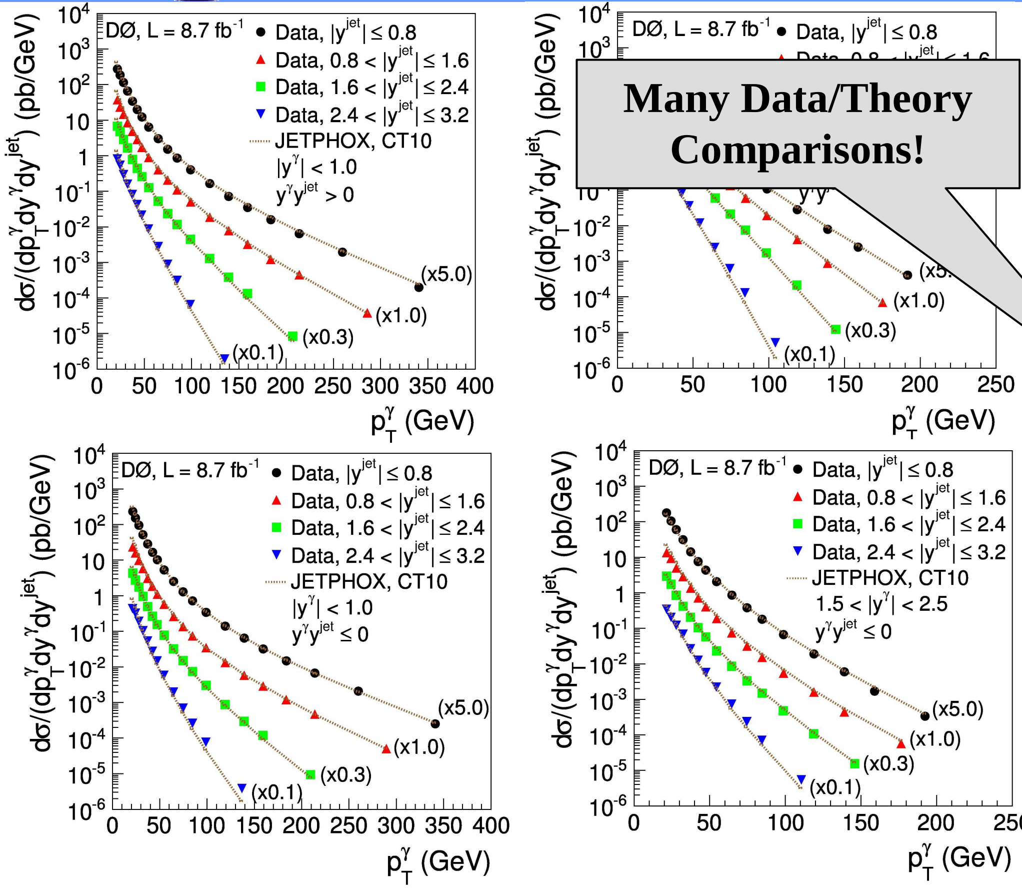
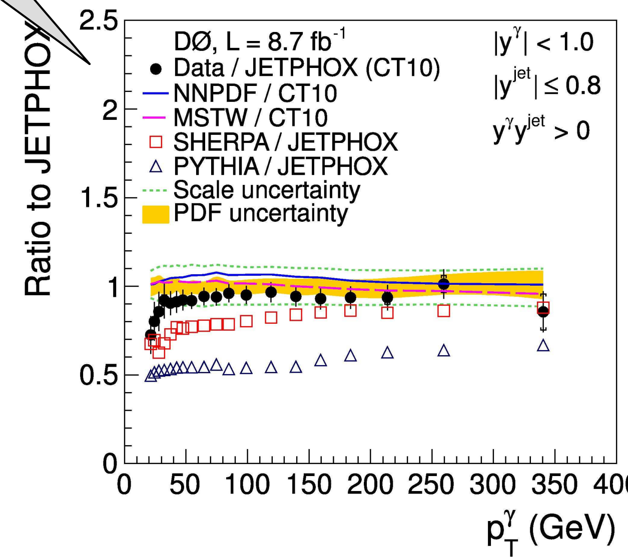
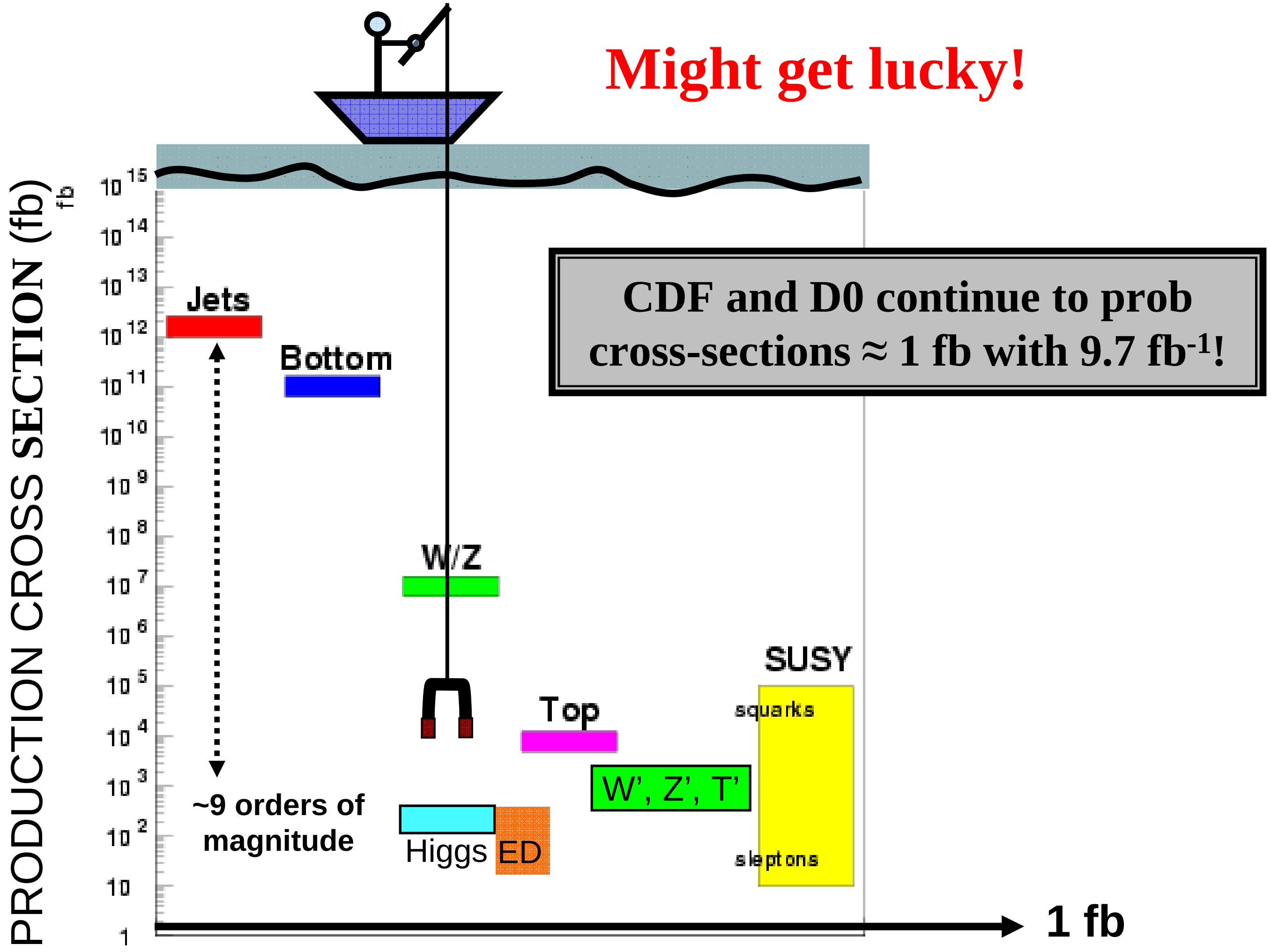
Many Data/Theory Comparisons!





- **D0 differential γ + jet cross section as a function of $p_T(\gamma)$ for four jet rapidity intervals, with central photons, $|y| < 1.0$, and forward photons, $1.5<|y|<2.5$, for same-sign and opposite-sign of photon and jet rapidities. For presentation purposes, cross sections for $|y_{jet}| \leq 0.8$, $0.8 < |y_{jet}| \leq 1.6$, $1.6 < |y_{jet}| \leq 2.4$ and $2.4 < |y_{jet}| \leq 3.2$ are scaled by factors of 5, 1, 0.3 and 0.1, respectively. The data are compared to the NLO QCD predictions using the jetphox with the CT10 PDF set and $\mu_R = \mu_F = \mu_f = p_T(\gamma)$.**

In Search of Rare Processes



W/Z + Upsilon Search

New since LHCP2013

- CDF search for the production of the Upsilon (1S) meson in association with a vector boson.

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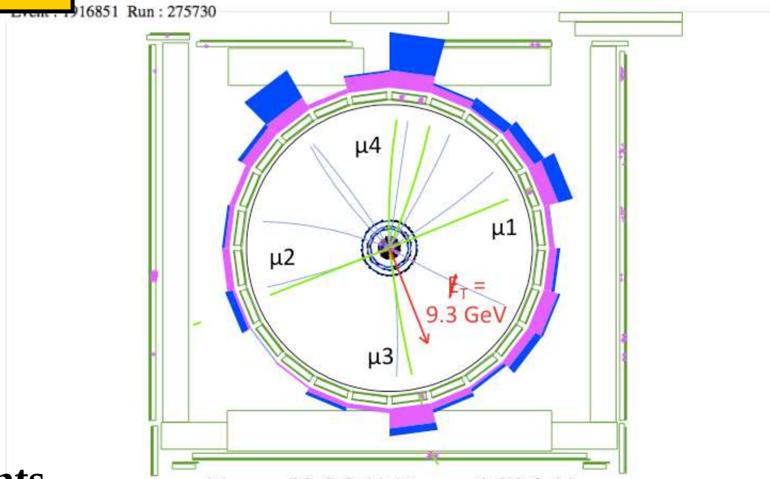
Υ+Z Candidate at CDF



$M_{\mu1\mu2}$ = 88.6 GeV, $M_{\mu3\mu4}$ = 9.26 GeV

Observe one Upsilon + W candidate over an expected background of 1.2 ± 0.5 events, and one Upsilon + Z candidate over an expected background of 0.1 ± 0.1 events.

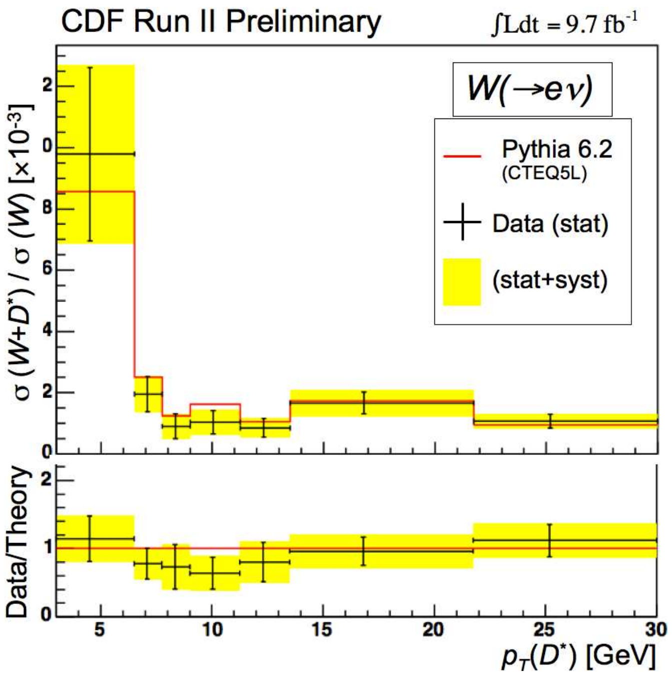
	$\Upsilon+W\to e\nu$	$\Upsilon+W\to\mu\nu$	$\Upsilon+W\to\ell\nu$	$\Upsilon+Z\to ee$	$\Upsilon+Z\to\mu\mu$	$\Upsilon+Z\to\ell\ell$
N_{sig}	0.019±0.004	0.014±0.003	0.034±0.006	0.0048±0.0009	0.0037±0.0007	0.0084±0.0016
N_{bg} (fake Υ)	0.7±0.4	0.4±0.3	1.1±0.5	0.07±0.07	0.04±0.04	0.1±0.1
N_{bg} (fake W/Z)	0.06±0.04	negl.	0.06±0.04	negl.	negl.	negl.
N_{bg} ($\Upsilon+Z$)	0.0006±0.0001	0.0033±0.0006	0.0039±0.0007			
N_{bg} (total)	0.8±0.4	0.4±0.3	1.2±0.5	0.07±0.07	0.04±0.04	0.1±0.1
N_{obs}	0	1	1	0	1	1

95% C.L. Cross Section Limits

	$\Upsilon+W$	$\Upsilon+Z$
expected limit (pb)	5.5	13
observed limit (pb)	5.5	20

Measurements of σ(V+D*)/σ(V)

New since LHCP2013



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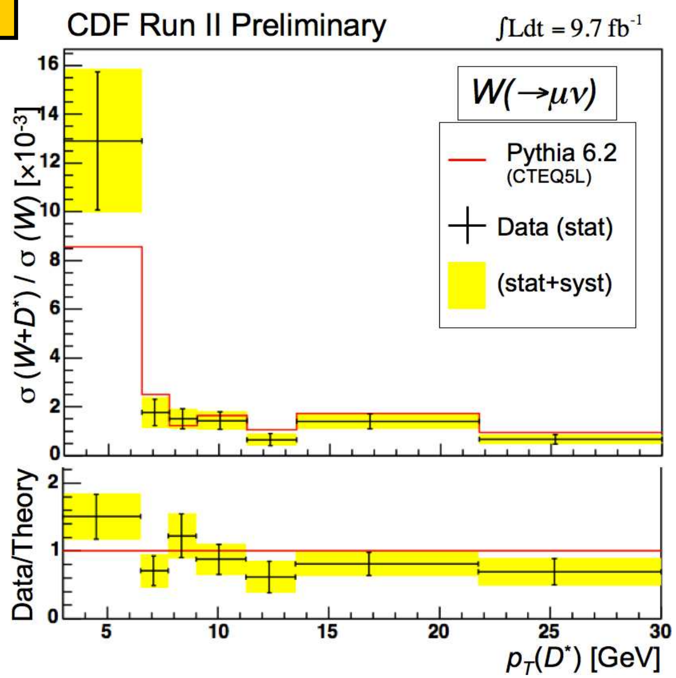
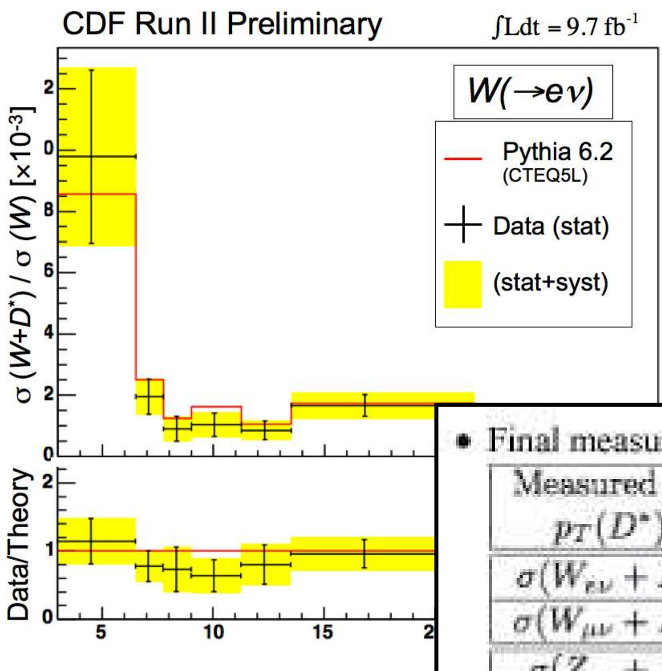


- **CDF data for the differential rates of cross-section ratio σ(W + D*)/σ(W) as a function of p_T (D*), as measured by in the W → eν (*left*) and W → μν (*right*) decay channels. The measurements show good agreement with PYTHIA 6.2 Tune A with (CTEQ5L) in all bins.**

Measurements of σ(V+D*)/σ(V)

New since LHCP2013



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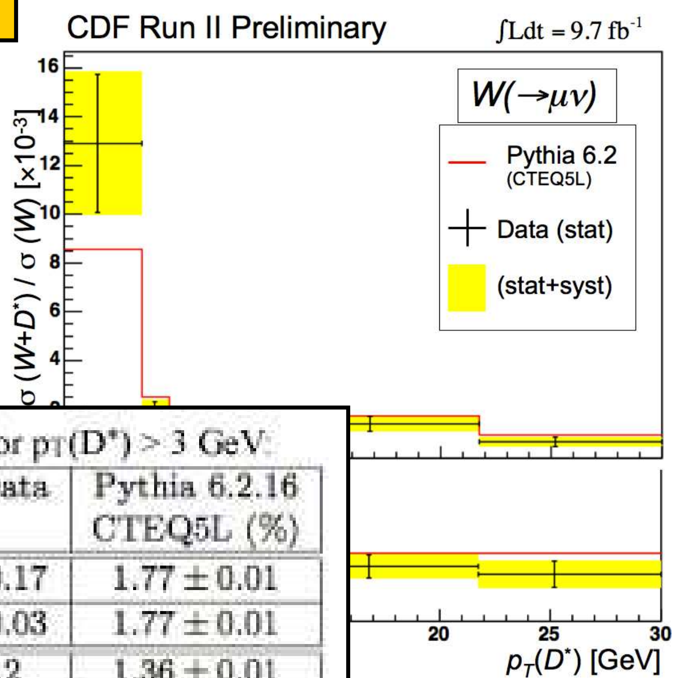


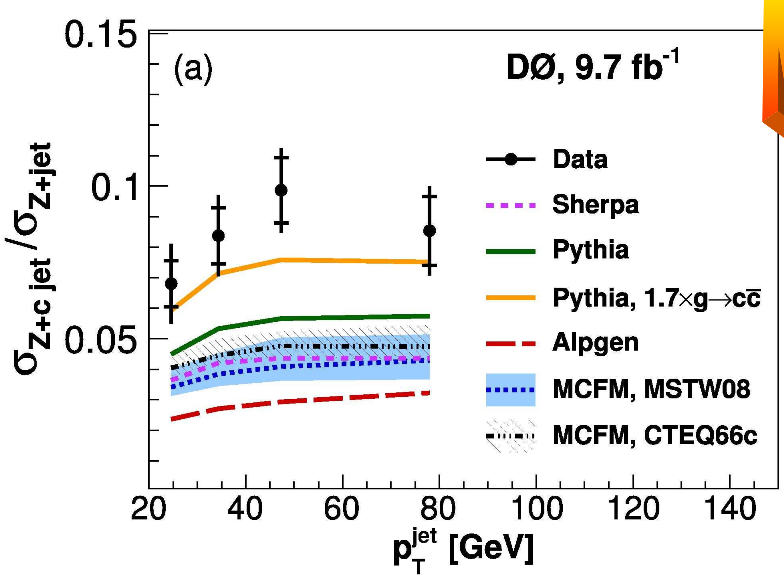
- Final measurements σ(W/Z+D*) / σ(W/Z) for $p_T(D^*) > 3$ GeV:

Measured quantity for $p_T(D^*) > 3$ GeV	CDF Run II Data (%)	Pythia 6.2.16 CTEQ5L (%)
$\sigma(W_{e\nu} + D^*)/\sigma(W_{e\nu})$	$1.74 \pm 0.21 \pm 0.17$	1.77 ± 0.01
$\sigma(W_{\mu\nu} + D^*)/\sigma(W_{\mu\nu})$	$1.75 \pm 0.17 \pm 0.03$	1.77 ± 0.01
$\sigma(Z_{ee} + D^*)/\sigma(Z_{ee})$	$1.0 \pm 0.6 \pm 0.2$	1.36 ± 0.01
$\sigma(Z_{\mu\mu} + D^*)/\sigma(Z_{\mu\mu})$	$1.8 \pm 0.5 \pm 0.2$	1.36 ± 0.01

➡ **CDF data for the differential rates of cross-section ratio σ(W + D*)/σ(W) as a function of p_T (D*), as measured by in the W → eν (*left*) and W → μν (*right*) decay channels. The measurements show good agreement with PYTHIA 6.2 Tune A with (CTEQ5L) in all bins.**

Measurements of Z + c-jet

New since LHCP2013



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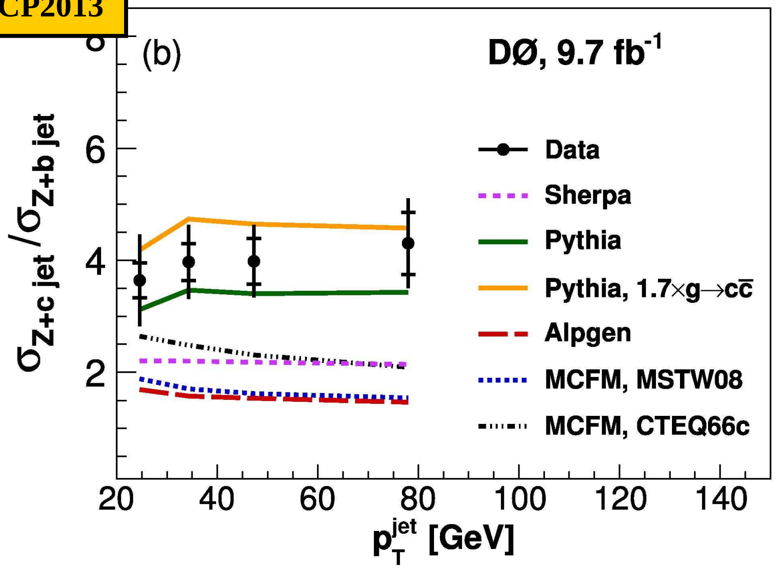
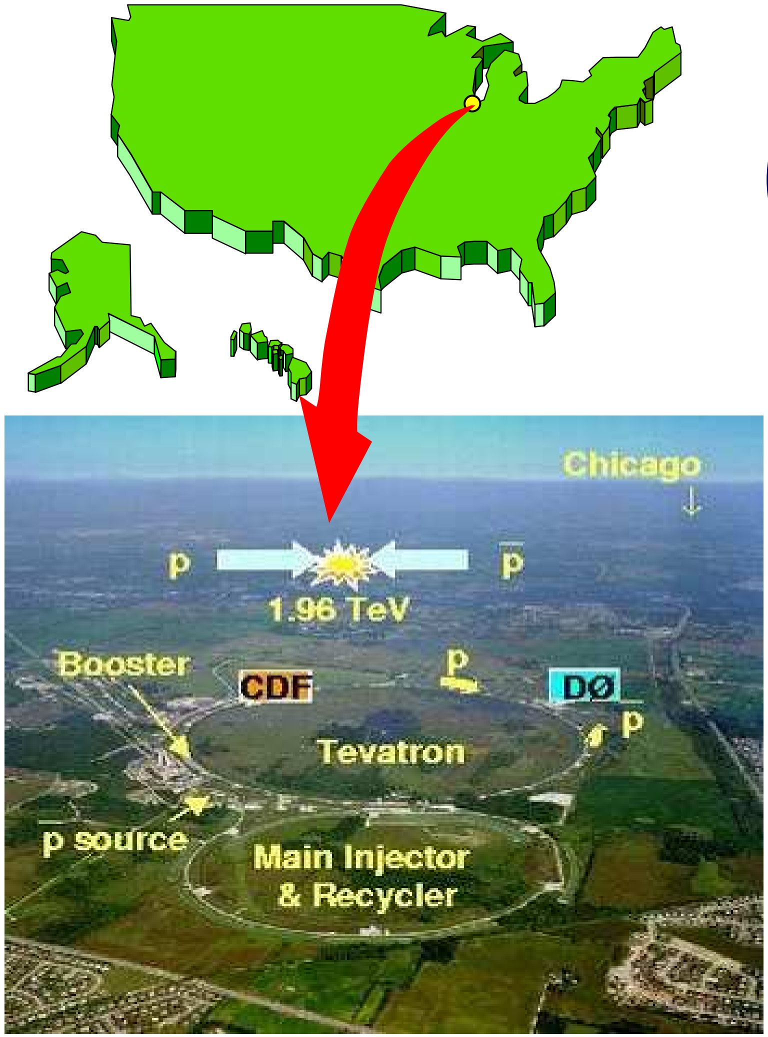
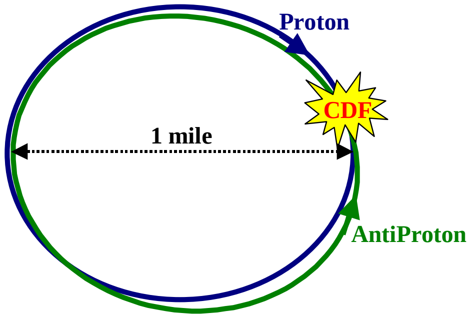


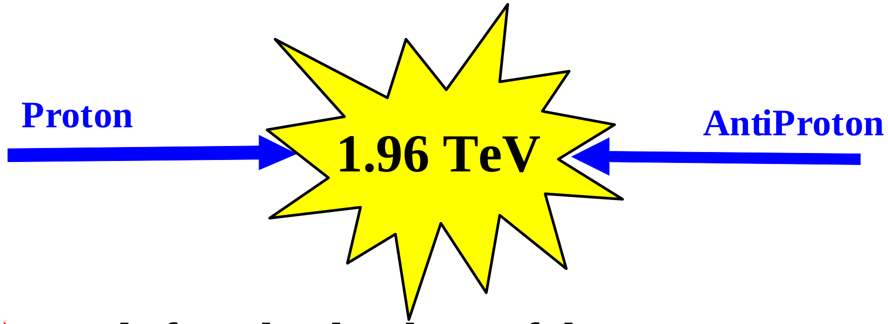
- **D0 differential cross-sections measurements $\sigma_{Z+c\text{-}jet}/\sigma_{Z+jet}$ (*left*) and $\sigma_{Z+c\text{-}jet}/\sigma_{Z+b\text{-}jet}$ (*right*) as a function of p_T(jet) (p_T(jet) > 20 GeV, $|\eta_{jet}| < 2.5$). Best agreement is with PYTHIA with 1.7 × enchanced g → cc rate.**

Phys. Rev. Lett. 112, 042001 (2014)

Tevatron Energy Scan





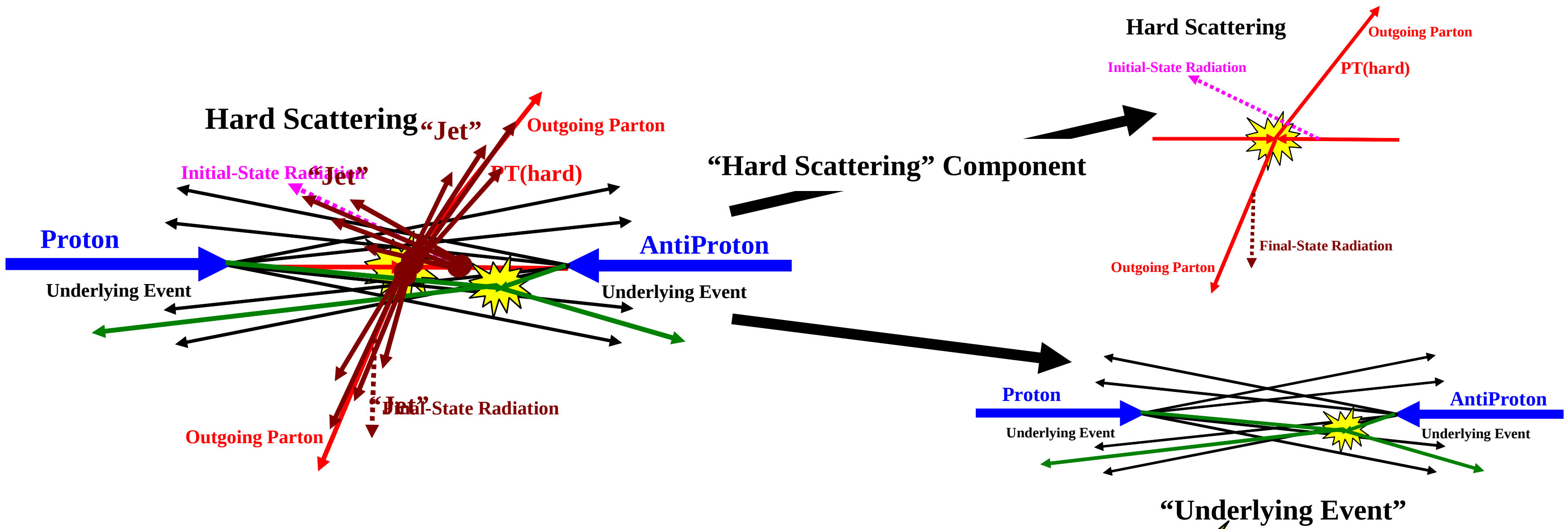


- **Just before the shutdown of the Tevatron CDF has collected more than 10M “min-bias” events at several center-of-mass energies!**

300 GeV 12.1M MB Events

900 GeV 54.3M MB Events

QCD Monte-Carlo Models: High Transverse Momentum Jets

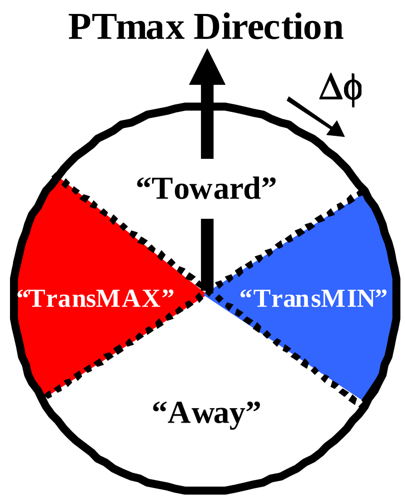


- Start with the perturbative 2-to-2 (or sometimes 2-to-3) parton-parton scatter g and add initial and final-state gluon radiation (in the leading log approximation or modified leadin approximation).
- The "underlying event" consists of the "beam-beam remnants" and articles arising from soft or semi-soft multiple parton interactions (MPI).
- Of course the outgoing colored parton bly "underlying event" observables receive contributions fron

The "underlying event" is an unavoidable background to most collider observables and having good understand of it leads to more precise collider measurements!

UE Observables

- **“transMAX” and “transMIN” Charged Particle Density:** Number of charged particles (p_T > 0.5 GeV/c, $|\eta|$ < 0.8) in the the maximum (minimum) of the two “transverse” regions as defined by the leading charged particle, PTmax, divided by the area in η-ϕ space, $2\eta_{cut}\times2\pi/6$, averaged over all events with at least one particle with p_T > 0.5 GeV/c, $|\eta| < \eta_{cut}$.
- **“transMAX” and “transMIN” Charged PTsum Density:** Scalar p_T sum of charged particles (p_T > 0.5 GeV/c, $|\eta|$ < 0.8) in the the maximum (minimum) of the two “transverse” regions as defined by the leading charged particle, PTmax, divided by the area in η-ϕ space, $2\eta_{cut}\times2\pi/6$, averaged over all events with at least one particle with p_T > 0.5 GeV/c, $|\eta| < \eta_{cut}$.



η_{cut} = 0.8

Overall “Transverse” = “transMAX” + “transMIN”

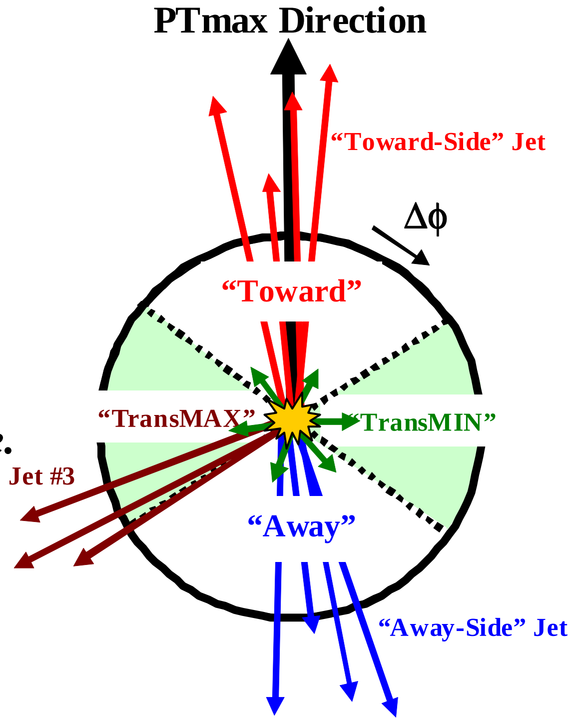
Note: The overall “transverse” density is equal to the average of the “transMAX” and “TransMIN” densities. The “TransDIF” Density is the “transMAX” Density minus the “transMIN” Density

“Transverse” Density = “transAVE” Density = (“transMAX” Density + “transMIN” Density)/2

“TransDIF” Density = “transMAX” Density - “transMIN” Density

"transMIN" & "transDIF"

- The "toward" region contains the leading "jet", while the "away" region, on the average, contains the "away-side" "jet". The "transverse" region is perpendicular to the plane of the hard 2-to-2 scattering and is very sensitive to the "underlying event". For events with large initial or final-state radiation the "transMAX" region defined contains the third jet while both the "transMAX" and "transMIN" regions receive contributions from the MPI and beam-beam remnants. Thus, the "transMIN" region is very sensitive to the multiple parton interactions (MPI) and beam-beam remnants (BBR), while the "transMAX" minus the "transMIN" (*i.e.* "transDIF") is very sensitive to initial-state radiation (ISR) and final-state radiation (FSR).



"TransMIN" density more sensitive to MPI & BBR.

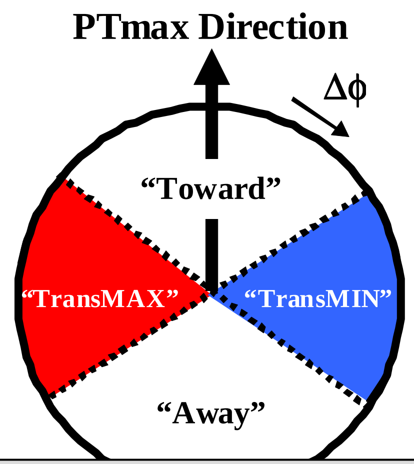
"TransDIF" density more sensitive to ISR & FSR.

0 ≤ "TransDIF" ≤ 2×"TransAVE"

"TransDIF" = "TransAVE" if "TransMIX" = 3×"TransMIN"

PTmax UE Data & Tunes

- **CDF PTmax UE Analysis:** "Towards", "Away", "transMAX", "transMIN", "transAVE", and "transDIF" charged particle and PTsum densities ($p_T > 0.5$ GeV/c, $|\eta| < 0.8$) in proton-antiproton collisions at 300 GeV, 900 GeV, and 1.96 TeV (R. Field analysis).
- **CMS PTmax UE Analysis:** "Towards", "Away", "transMAX", "transMIN", "transAVE", and "transDIF" charged particle and PTsum densities ($p_T > 0.5$ GeV/c, $|\eta| < 0.8$) in proton-proton collisions at 900 GeV and 7 TeV (Mohammed Zakaria Ph.D. Thesis, CMS PAS FSQ-12-020).
- **New Herwig++ Tune:** M. Seymour and A. Siódmok have used the CDF UE data at 300 GeV, 900 GeV, and 1.96 TeV together with LHC UE data at 7 TeV to construct a new and improved Herwig++ tune.
- **New PYTHIA 8 Monash Tune:** P. Skands, S. Carrazza, and J. Rojo have used the CDF UE data at 300 GeV, 900 GeV, and 1.96 TeV together with LHC data at 7 TeV to construct a new PYTHIA 8 tune (NNPDF2.3LO PDF).
- **New CMS UE Tunes:** CMS has used the CDF UE data at 300 GeV, 900 GeV, and 1.96 TeV together wth CMS UE data at 7 TeV to construct a new PYTHIA 6 tune (CTEQ6L) and two new PYTHIA 8 tunes (CTEQ6L and HERAPDF1.5LO PDF).

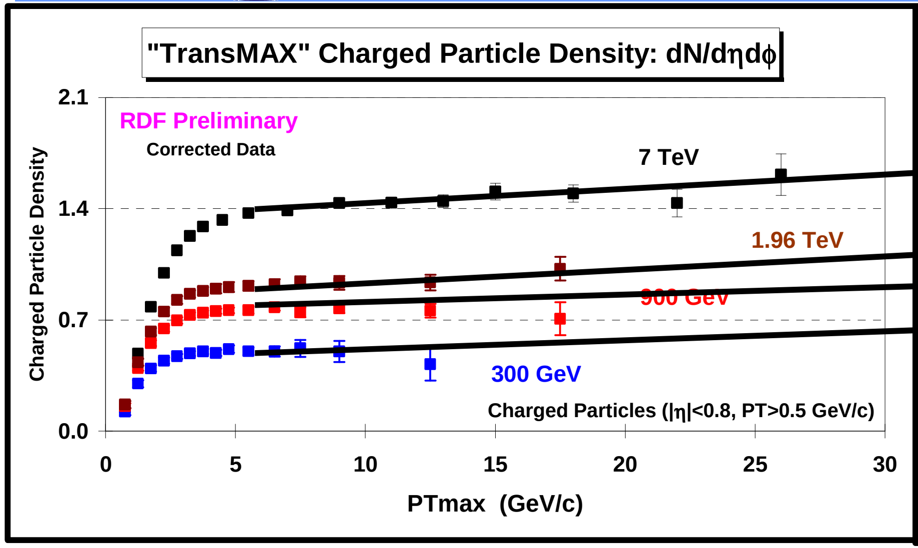


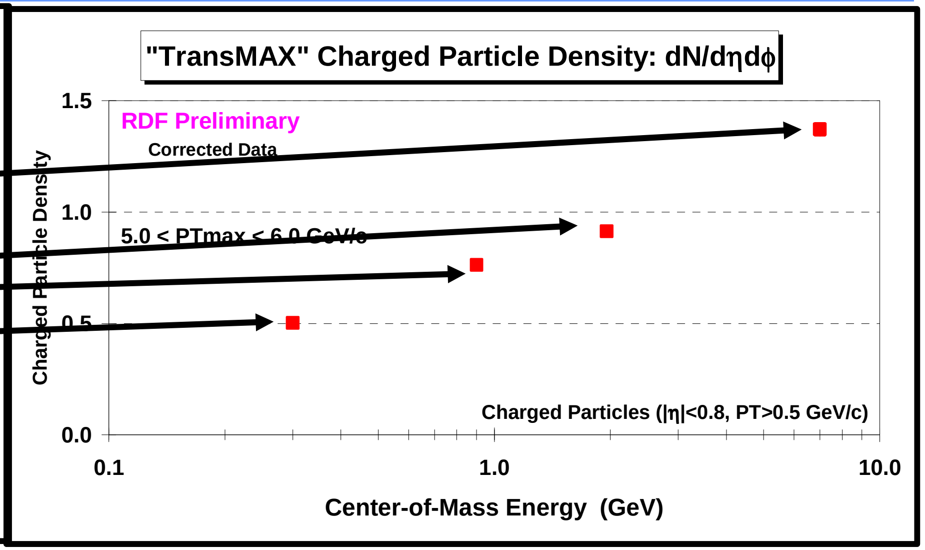
arXiv:1307.5015 [hep-ph]

arXiv:1404.5630 [hep-ph]

CMS-PAS-GEN-14-001

“transMAX” NchgDen vs E_{cm}

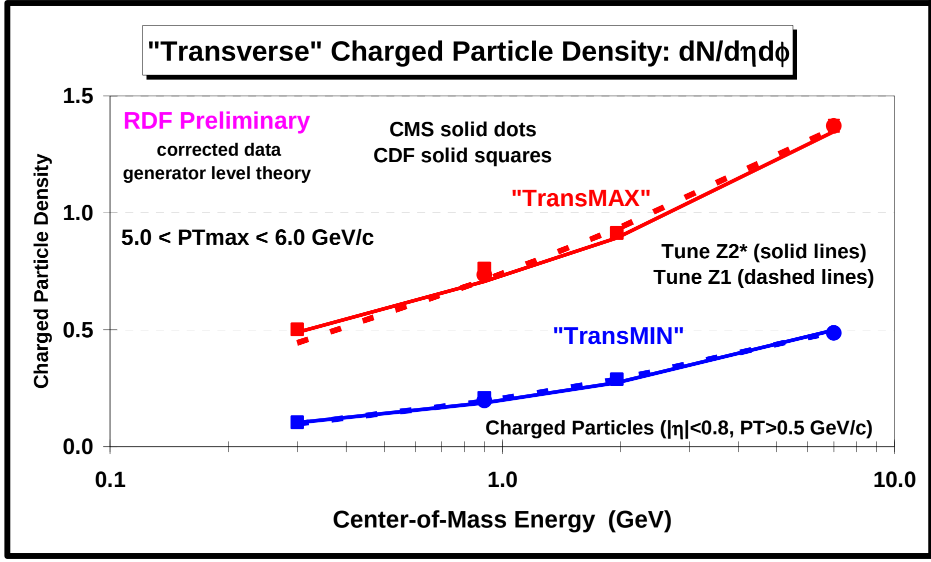


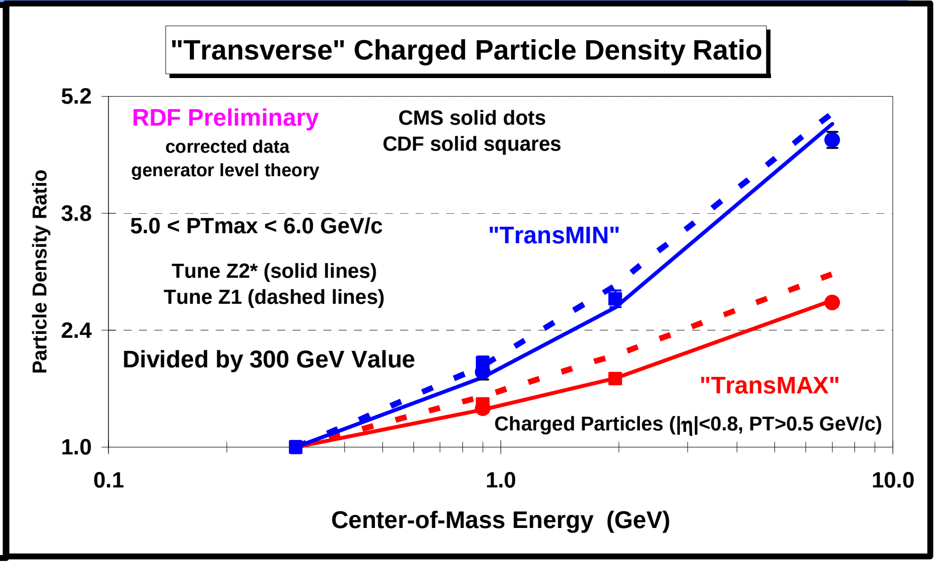


- Corrected CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the “transMAX” region as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8. The data are corrected to the particle level with errors that include both the statistical error and the systematic uncertainty.

- Corrected CMS and CDF data on the charged particle density in the “transMAX” region as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8 with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).

"Transverse" NchgDen vs E_{cm}



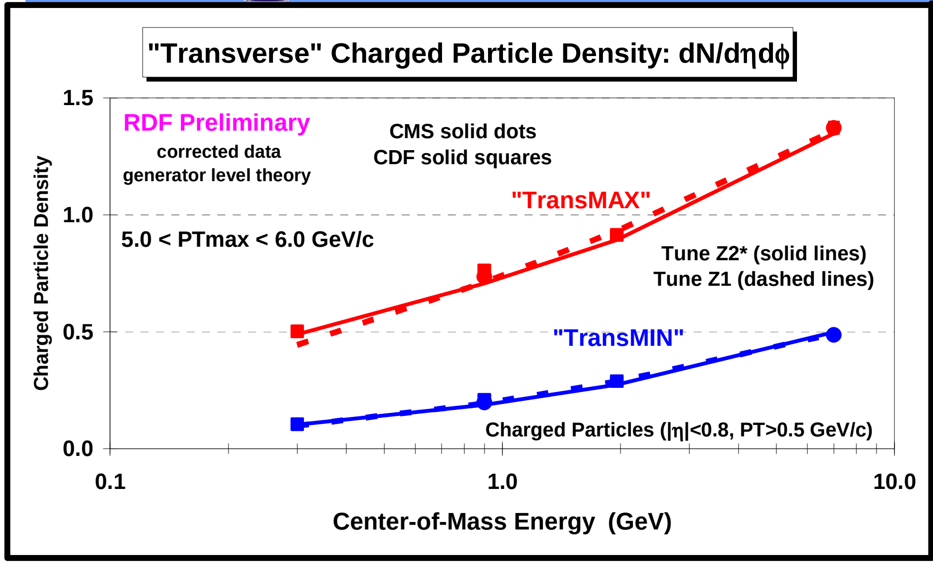


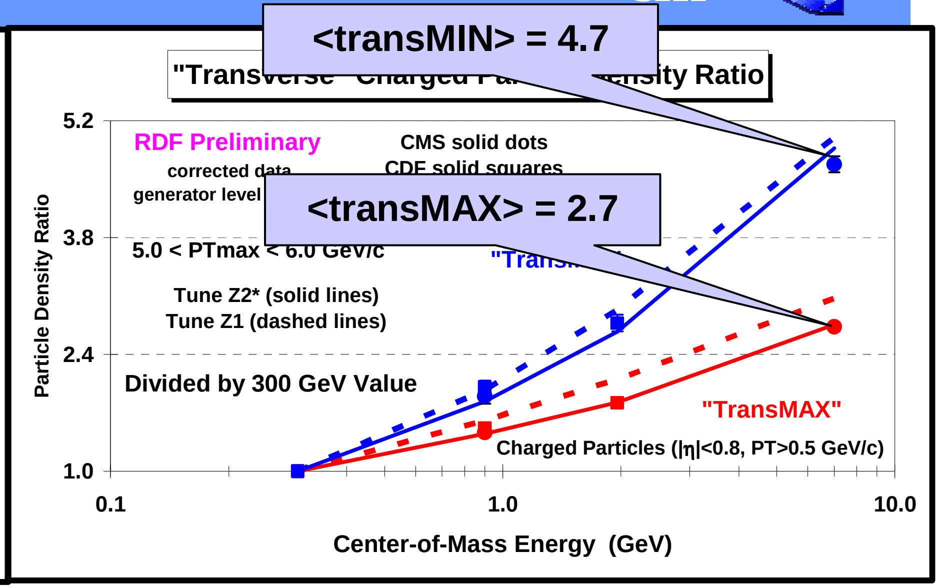
- **Corrected CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the "transMAX" and "transMIN" regions as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8 with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).**

- **Ratio of CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV to the value at 300 GeV for the charged particle density in the "transMAX" and "transMIN" regions as defined by the leading charged particle (PTmax) for charged particles with p_T > 0.5 GeV/c and |η| < 0.8 with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).**

The data are compared with PYTHIA 6.4 Tune Z1 and Tune Z2*.

"Transverse" NchgDen vs E_{cm}



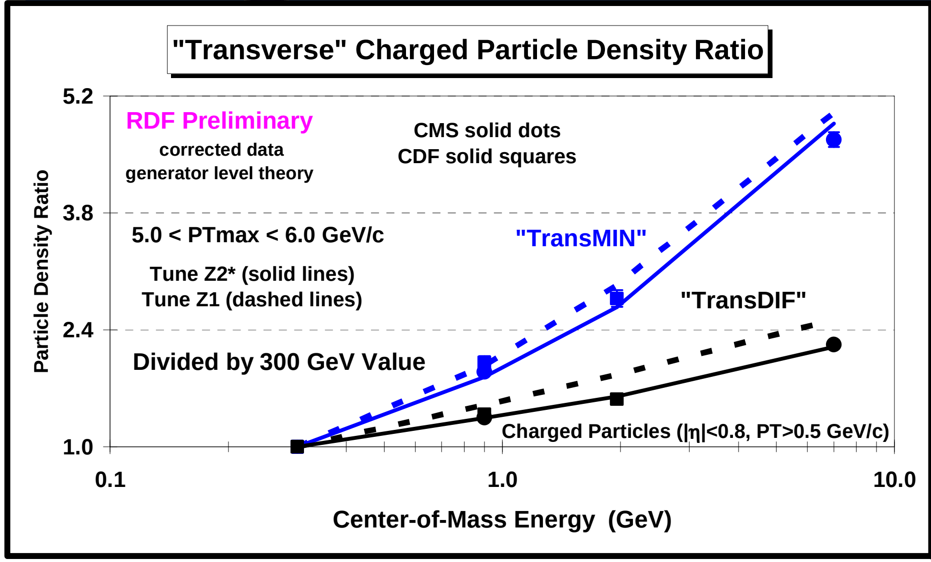


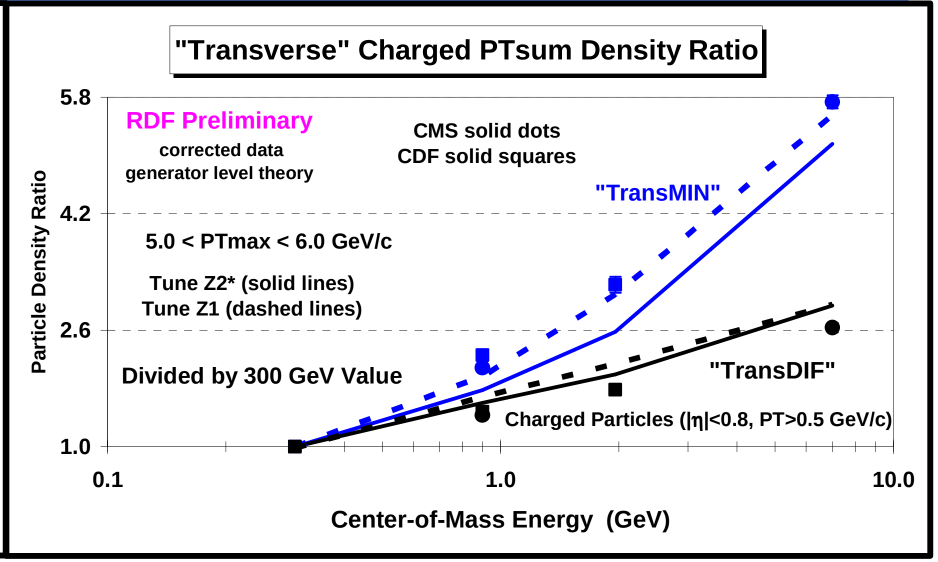
- Corrected CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV on the charged particle density in the "transMAX" and "transMIN" regions as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).

- Ratio of CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV to the value at 300 GeV for the charged particle density in the "transMAX" and "transMIN" regions as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).

The data are compared with PYTHIA 6.4 Tune Z1 and Tune Z2*.

“TransMIN/DIF” vs E_{cm}



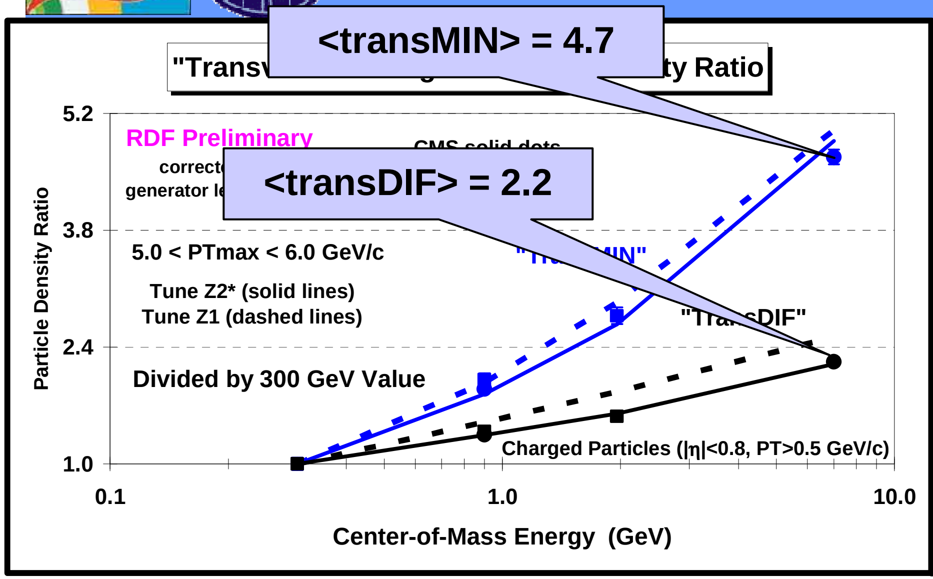


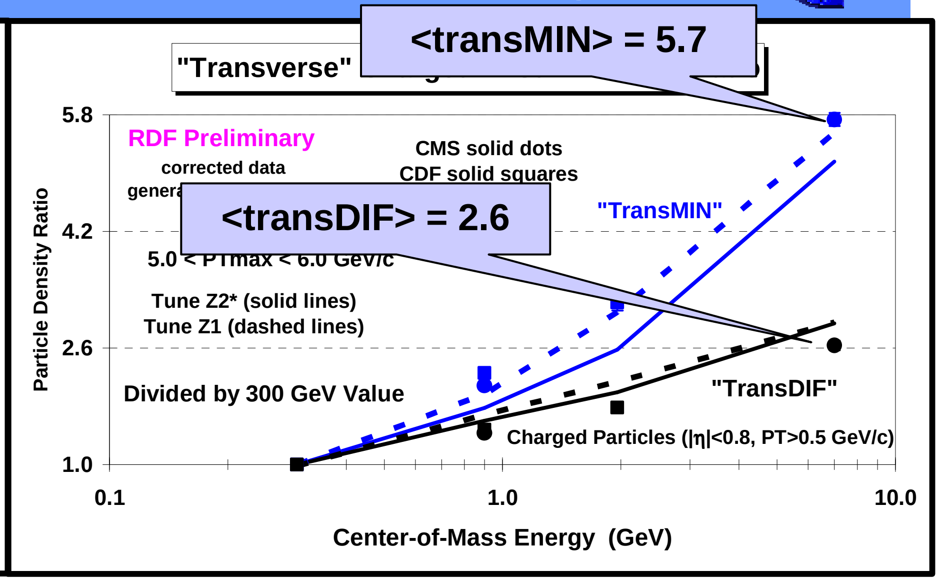
- **Ratio of CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV to the value at 300 GeV for the charged particle density in the “transMIN”, and “transDIF” regions as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).**

- **Ratio of CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV to the value at 300 GeV for the charged PTsum density in the “transMIN”, and “transDIF” regions as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).**

The data are compared with PYTHIA 6.4 Tune Z1 and Tune Z2*.

"TransMIN/DIF" vs E_{cm}



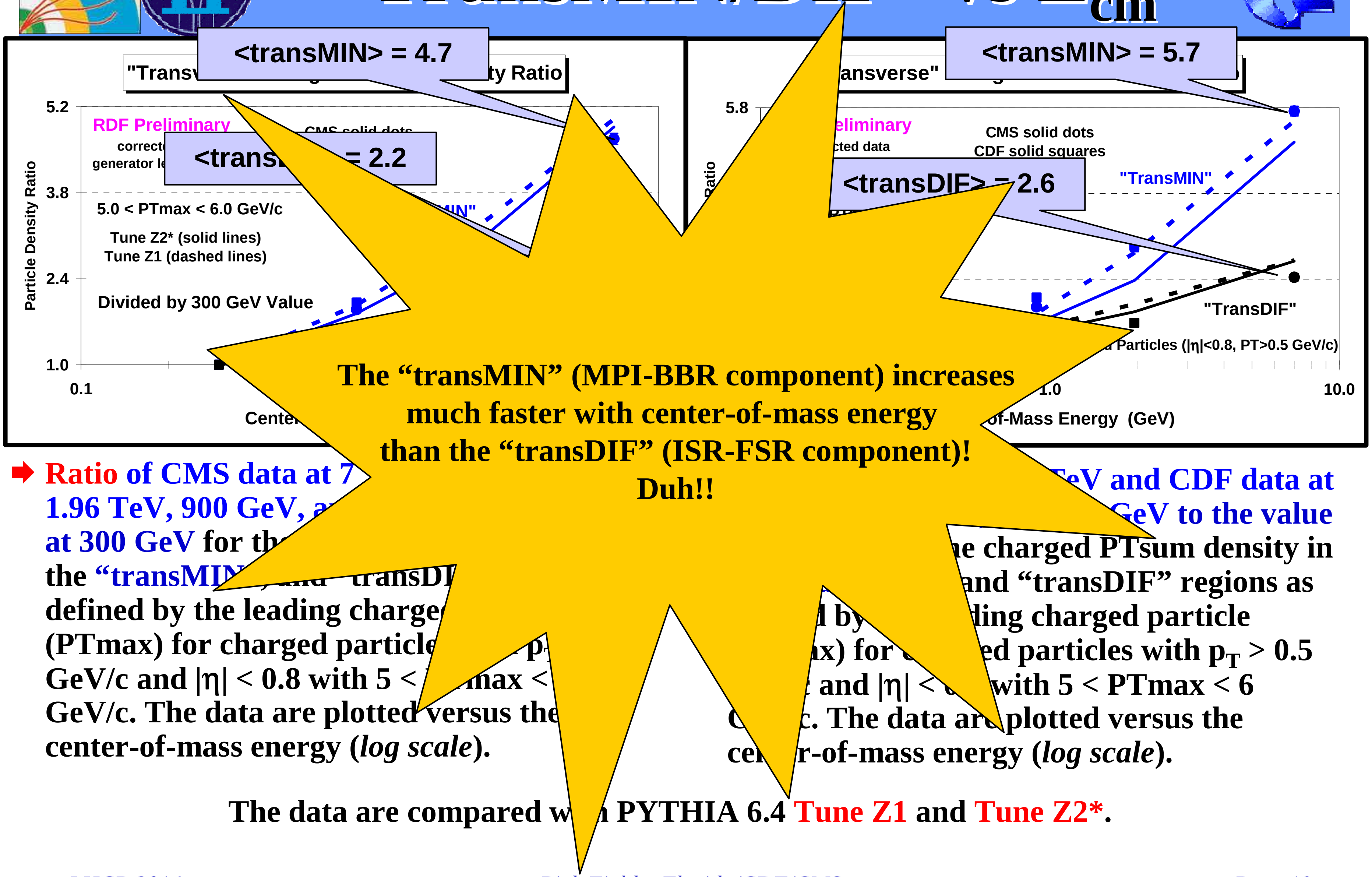


- **Ratio of CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV to the value at 300 GeV for the charged particle density in the "transMIN", and "transDIF" regions as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).**

- **Ratio of CMS data at 7 TeV and CDF data at 1.96 TeV, 900 GeV, and 300 GeV to the value at 300 GeV for the charged PTsum density in the "transMIN", and "transDIF" regions as defined by the leading charged particle (PTmax) for charged particles with $p_T > 0.5$ GeV/c and $|\eta| < 0.8$ with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).**

The data are compared with PYTHIA 6.4 Tune Z1 and Tune Z2*.

"TransMIN/DIF" vs E_{cm}

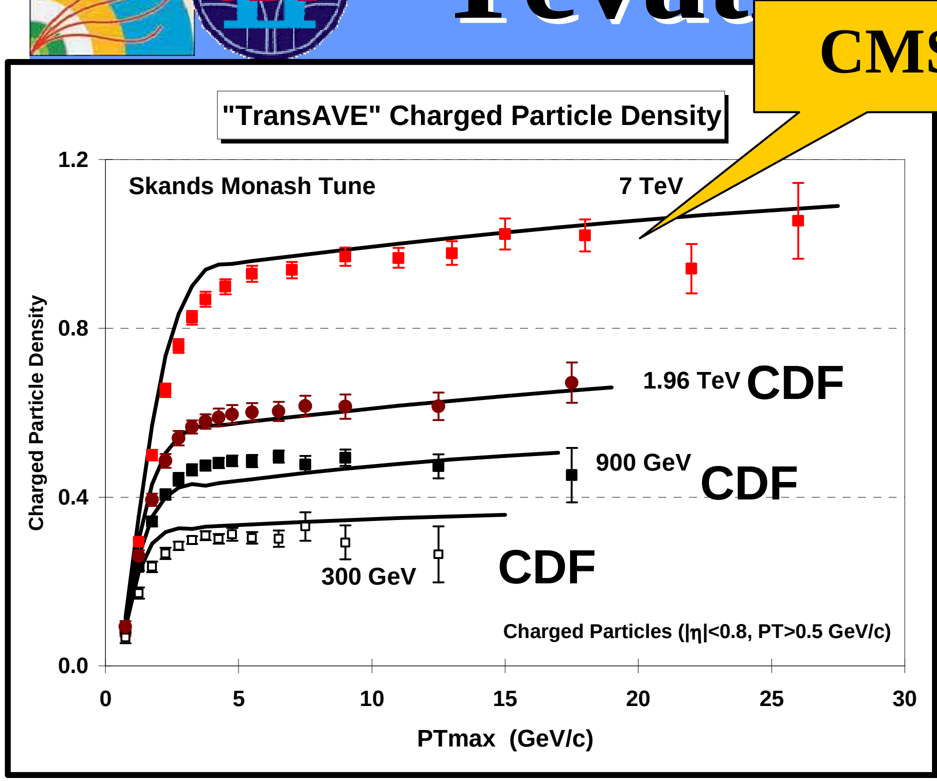


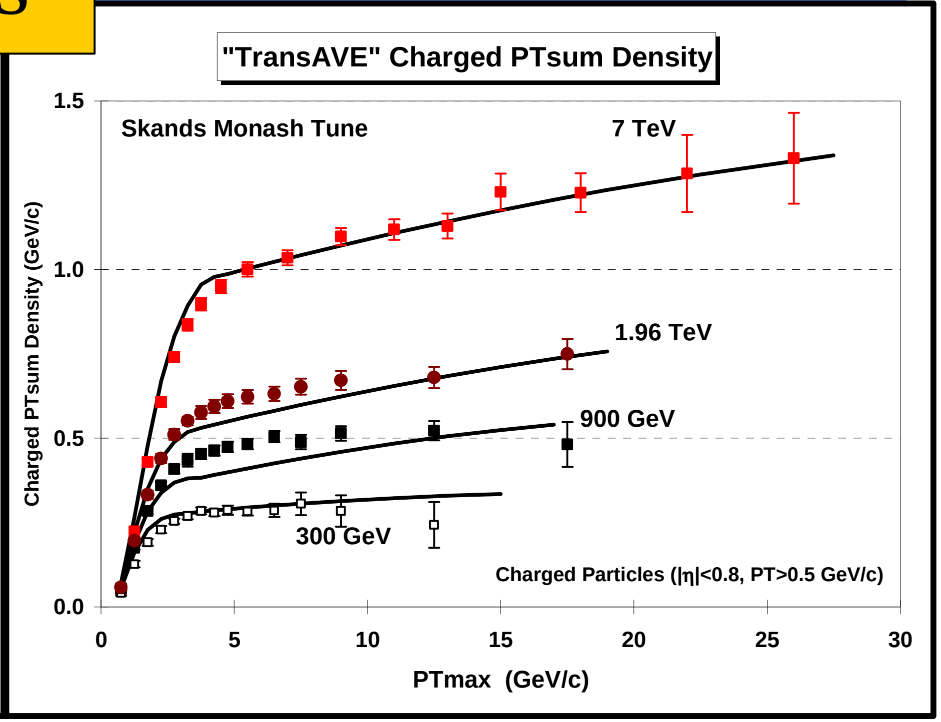
- Ratio of CMS data at 7 … 1.96 TeV, 900 GeV, a… at 300 GeV for th… the "transMIN", and "transDI… defined by the leading charge… (PTmax) for charged particle… p_T… GeV/c and |η| < 0.8 with 5 < PTmax < … GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).

… TeV and CDF data at … GeV to the value … the charged PTsum density in … and "transDIF" regions as … by … ding charged particle … ax) for … ed particles with p_T > 0.5 … and |η| < … with 5 < PTmax < 6 GeV/c. The data are plotted versus the center-of-mass energy (*log scale*).

The data are compared w… PYTHIA 6.4 Tune Z1 and Tune Z2*.

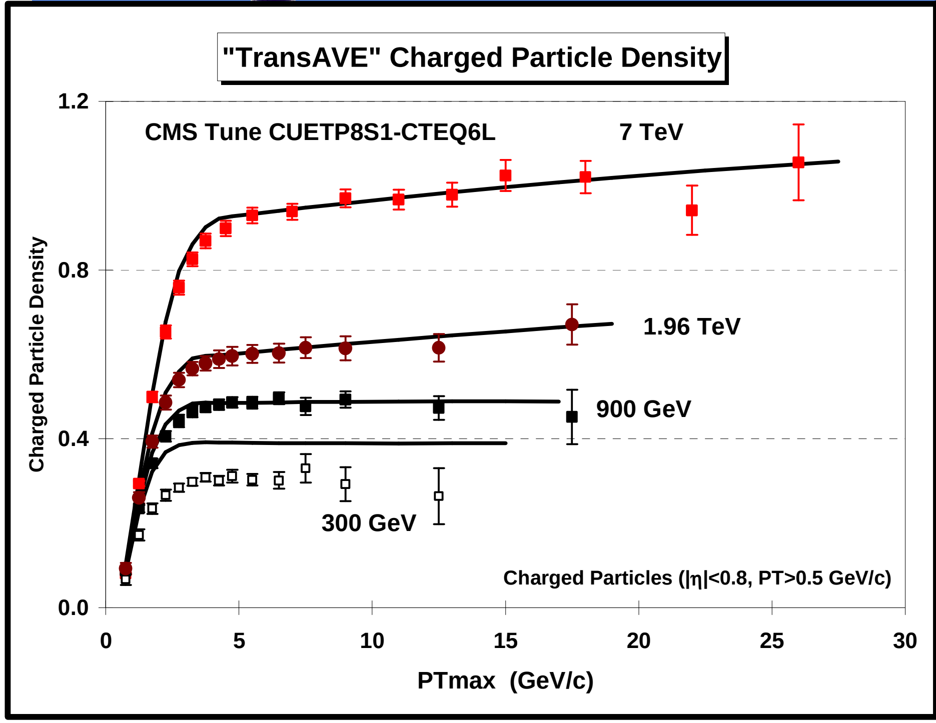
"Tevatron" to the LHC

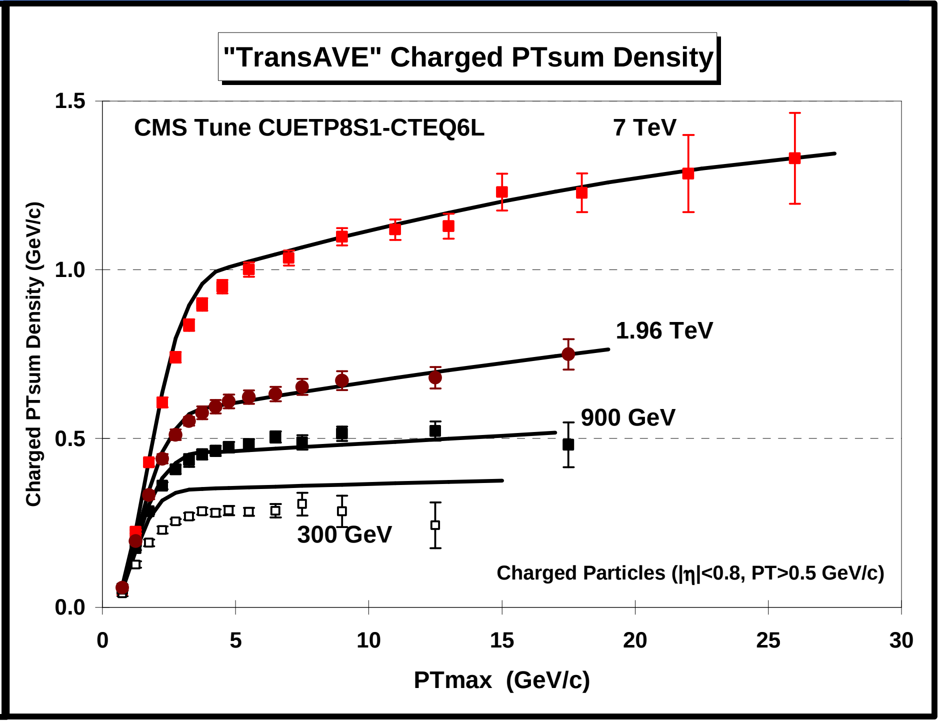




- **Shows the "transAVE" charged particle density as defined by the leading charged particle, PTmax, as a function of PTmax at 300 GeV, 900 GeV, 1.96 TeV, and 7 TeV compared with the Skands Monash tune.**
- **Shows the "transAVE" charged PTsum density as defined by the leading charged particle, PTmax, as a function of PTmax at 300 GeV, 900 GeV, 1.96 TeV, and 7 TeV compared with the Skands Monash tune.**

“Tevatron” to the LHC





- Shows the “transAVE” charged particle density as defined by the leading charged particle, PTmax, as a function of PTmax at 300 GeV, 900 GeV, 1.96 TeV, and 7 TeV compared with the CMS tune CUETP8S1-CTEQ6L.
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Findings & Surprises

- The "transverse" density increases faster with center-of-mass energy than the overall density (Nchg $\geq$ 1)! However, the "transverse" = "transAVE" region is not a true measure of the energy dependence of MPI since it receives large contributions from ISR and FSR.

- The "transMIN" (MPI-BBR component) increases much faster with center-of-mass energy than the "transDIF" (ISR-FSR component)! Previously we only knew the energy dependence of "transAVE".

We now have at lot of MB & UE data at 300 GeV, 900 GeV, 1.96 TeV, and 7 TeV! We can study the energy dependence more precisely than ever before!

Findings & Surprises

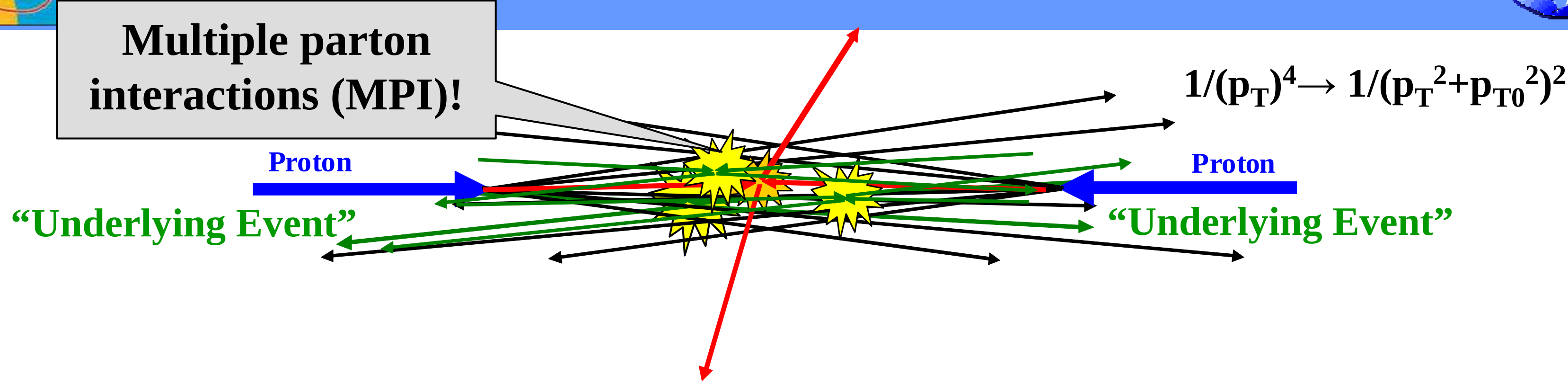
- The "transverse" density increases faster with center-of-mass energy than the overall density (Nchg ≥ 1). However, the "transverse" = "transAVE" region is not ... measure ... energy dependence of MPI since it receives large c... ns...

- The "transMIN" (... faster with center-of-ma... ...usly we only knew ...

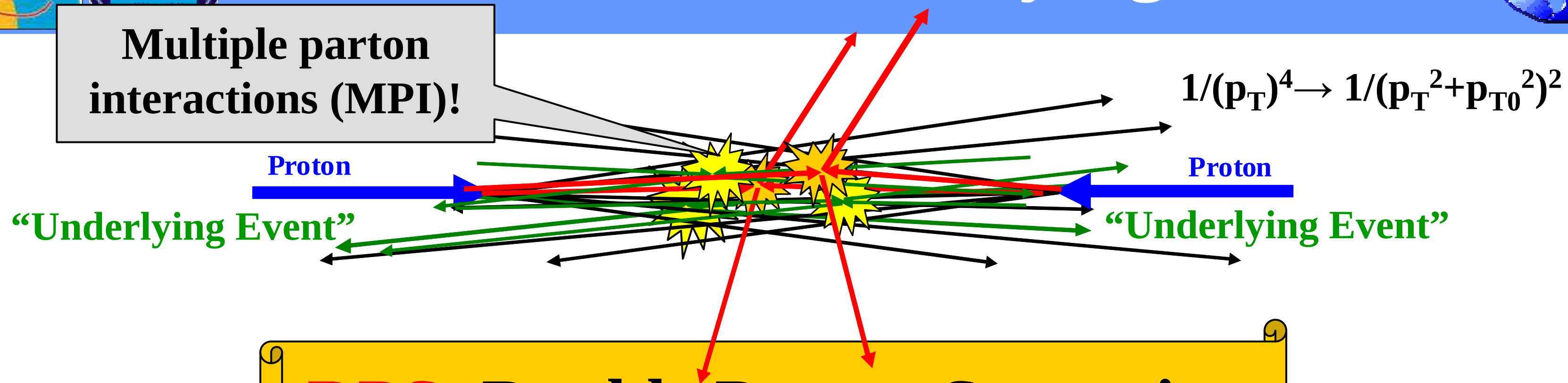
What we are learning should allow for a deeper understanding of MPI which will result in more precise predictions at the future LHC energies of 13 & 14 TeV!

... 900 GeV ... TeV! We ca... pe... m... pre... than... before.

DPS and the "Underlying Event"



DPS and the "Underlying Event"



DPS: Double Parton Scattering

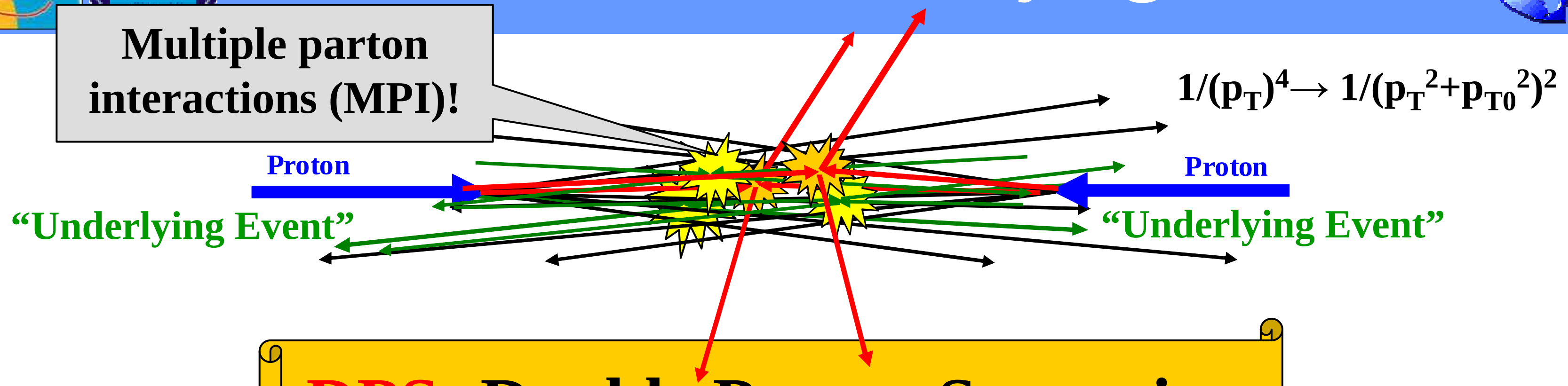
Most of the time MPI are much "softer" than the primary "hard" scattering, however, occasionally two "hard" 2-to-2 parton scatterings can occur within the same hadron-hadron. This is referred to as double parton scattering (DPS) and is typically described in terms of an effective cross section parameter, σ_{eff}, defined as follows:

$$\sigma_{AB} = \frac{\sigma_A \sigma_B}{\sigma_{eff}}$$

Independent of A and B

where σ_A and σ_B are the inclusive cross sections for individual hard scatterings of type A and B, respectively, and σ_{AB} is the inclusive cross section for producing both scatterings in the same hadron-hardon collision. If A and B are indistinguishable, as in 4-jet production, a statistical factor of ½ must be inserted.

DPS and the "Underlying Event"



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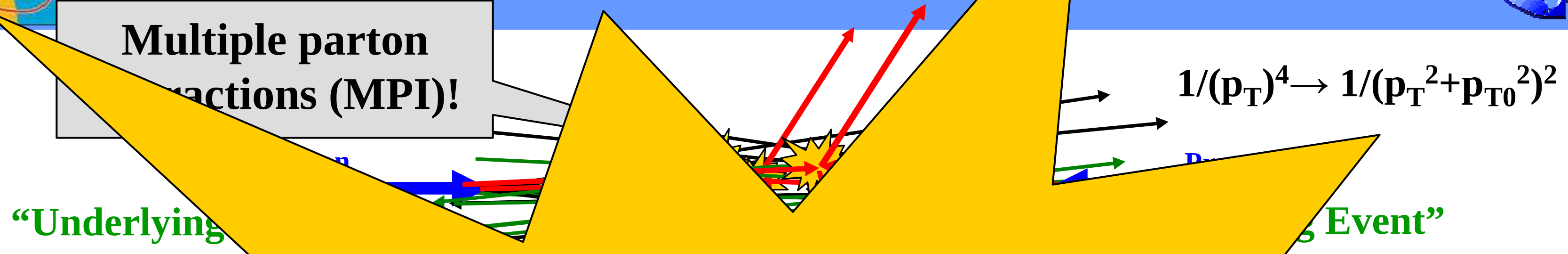
DPS and the “Underlying Event”

Multiple parton ...actions (MPI)!



Having determined the parameters of an MPI model, one can make an unambiguous prediction of σ_{eff}. In PYTHIA 8 σ_{eff} depends primarily on the matter overlap function, which for bProfile = 3 is determined by the exponential shape parameter, expPow, and the MPI cross section determined by p_{T0} and the PDF.

Most of the tim... however, occasionally two... n- hadron. Th... pically described in terms o... ective cross...

...ndependen... nd B

σ_{eff}

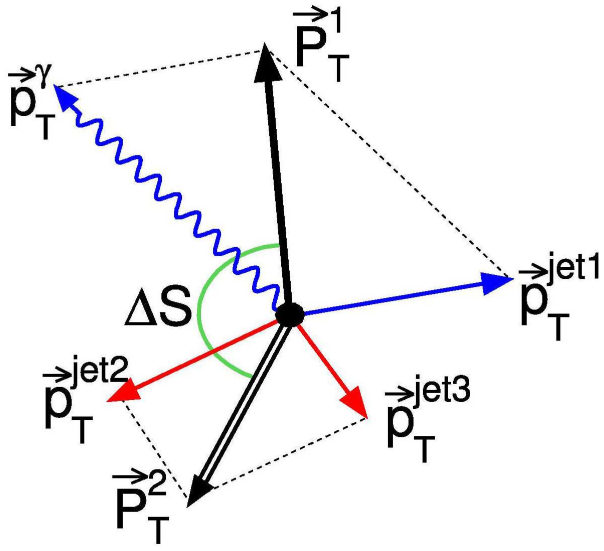
where σ_A and σ_B are the inclusive ... sections fo... vidual hard scatterings of type A and B, respectively, and σ_{AB} is the ... sive cross sec... n for producing both scatterings in the same hadron-hardon collisio... If A and B are indistinguishable, as in 4-jet production, a statistical factor of ½ must be inserted.

DPS Observables

- Direct measurements of σ_{eff} are performed by studying correlations between the outgoing objects in hadron-hadron collision. Two correlation observables that are sensitive to DPS are ΔS and $\Delta^{rel}p_T$ defined as follows:

$$\Delta S = \arccos\left(\frac{\vec{p}_T(object\#1)\cdot\vec{p}_T(object\#2)}{\left|\vec{p}_T(object\#1)\right|\times\left|\vec{p}_T(object\#2)\right|}\right)$$

$$\Delta^{rel}p_T = \frac{\left|\vec{p}_T^{\,jet\#1}+\vec{p}_T^{\,jet\#2}\right|}{\left|\vec{p}_T^{\,jet\#1}\right|+\left|\vec{p}_T^{\,jet\#2})\right|}$$



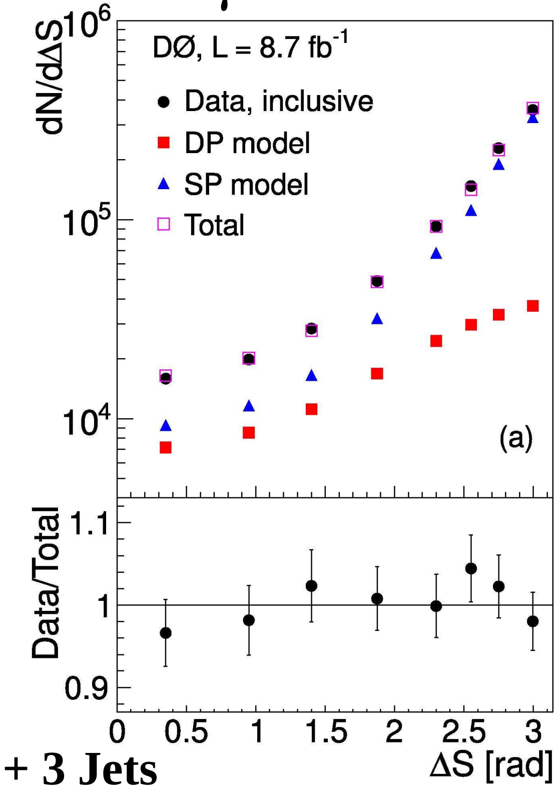
For γ+3jets object#1 is the photon and the leading jet (jet1) and object#2 is jet2 and jet3. For W+dijet production object#1 is the W-boson and object#2 dijet. For 4-jet production object#1 is hard-jet pair and object#2 is the soft-jet pair. For $\Delta^{rel}p_T$ in W+dijet production jet#1 and jet#2 are the two dijets, while in 4-jet production jet#1 and jet#2 are the softer two jets.

DPS in γ + 3 Jets and γ +b/c + 2 Jets

New

since LHCP2013

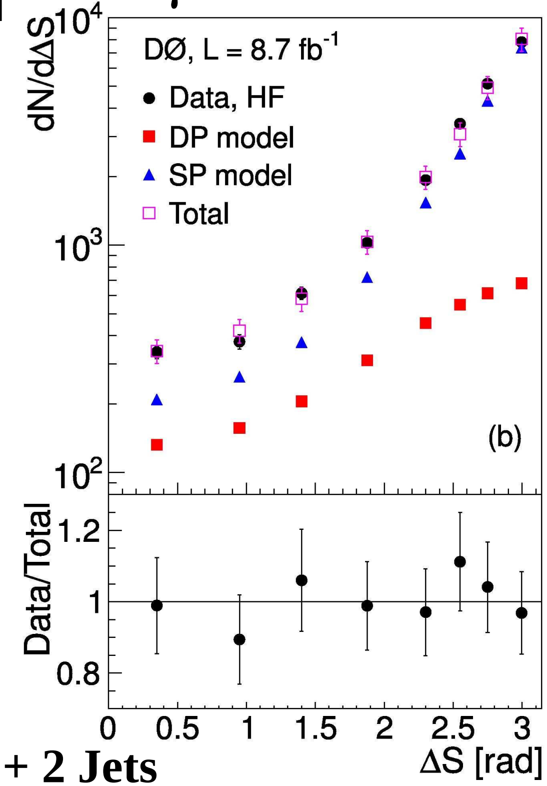
γ + 3 Jets



γ + 3 Jets

σ_{eff} = 12.7 ± 0.2 (stat) ± 1.3 (syst) mb

γ + b/c + 2 Jets



γ + b/c + 2 Jets

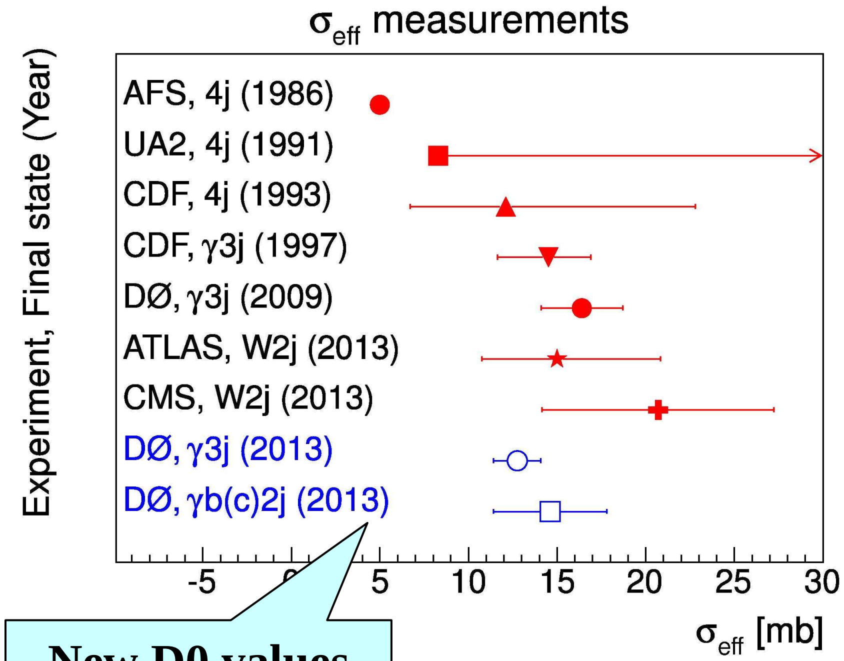
σ_{eff} = 14.6 ± 0.6 (stat) ± 3.2 (syst) mb

8.7 fb-1

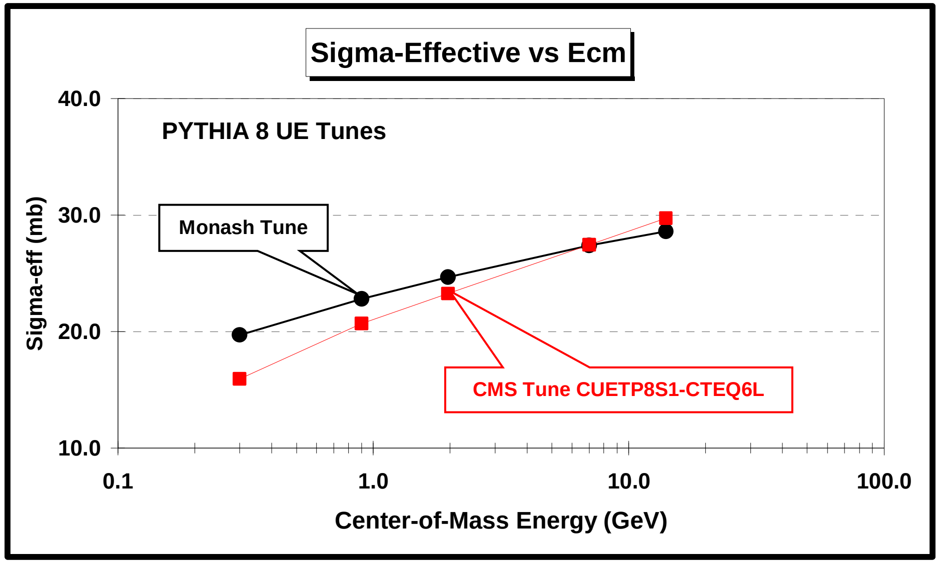
Phys. Rev. D 89, 072006 (2014)

➡ Combine single parton scattering (SP) and double parton scattering (DP) and determine rhe fraction of DP necessary to fit the shape of the ΔS distribution.

Sigma-Effective

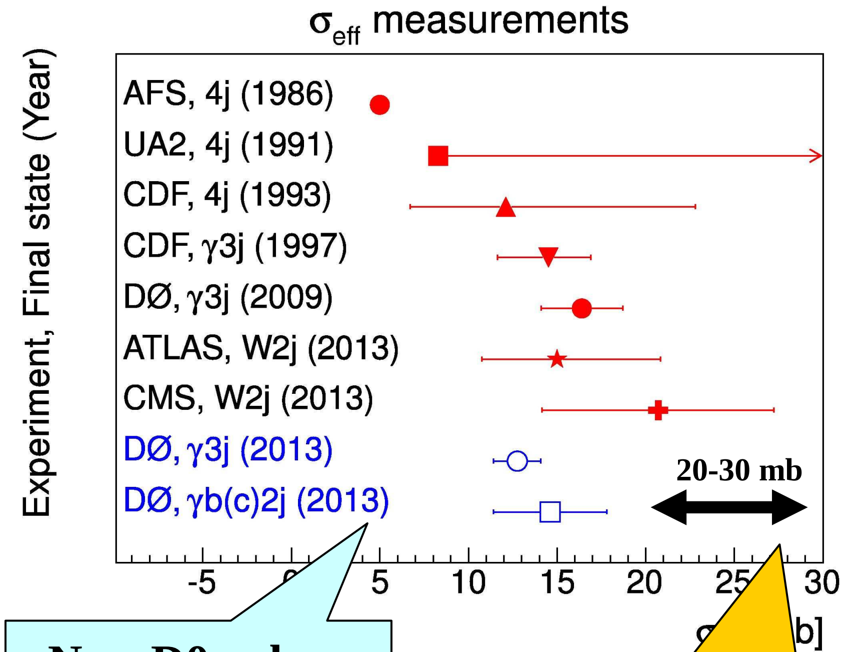


New D0 values



- Shows the σ_{eff} values caluclated from the PYTHIA 8 Monash and CMS tune CUETP8S1-CTEQ6L.

Sigma-Effective



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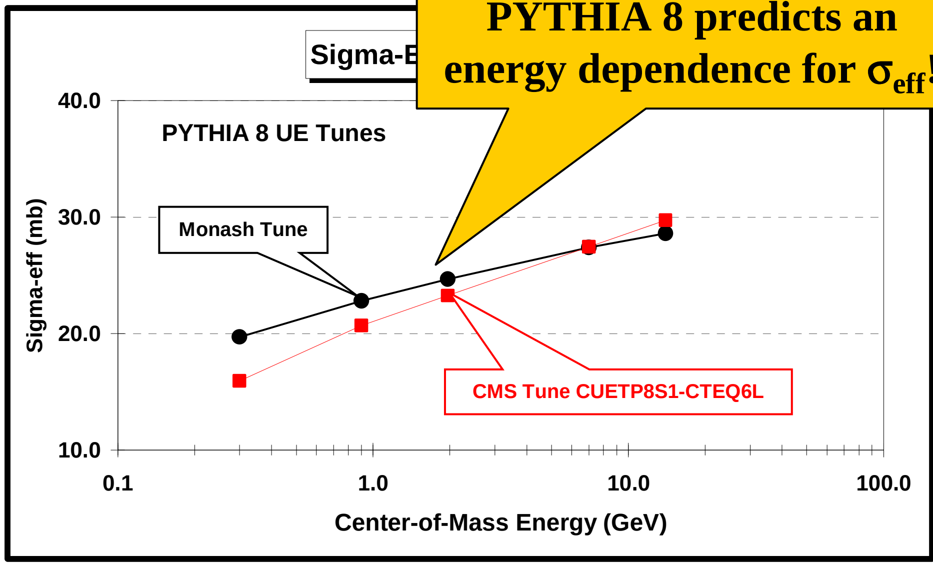
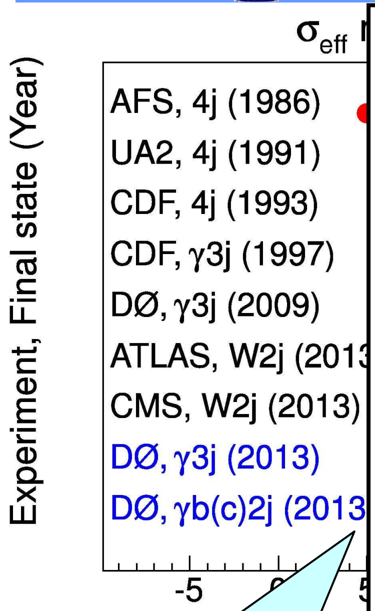


PYTHIA 8 predicts an energy dependence for σ_{eff}!

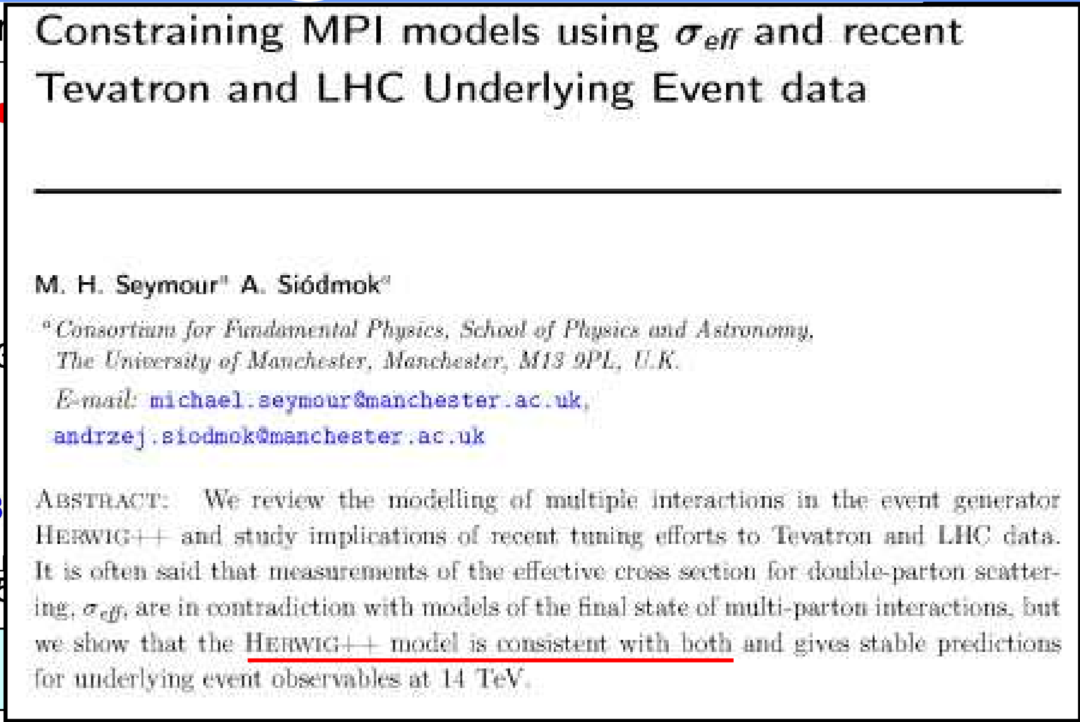
- Shows the σ_{eff} values calculated from the PYTHIA 8 Monash and CMS tune CUETP8S1-CTEQ6L.

The σ_{eff} predicted from the PYTHIA 8 UE tunes is slightly larger than the direct measurements!

Sigma-Effective



New D0 values



Constraining MPI models using σ_{eff} and recent Tevatron and LHC Underlying Event data

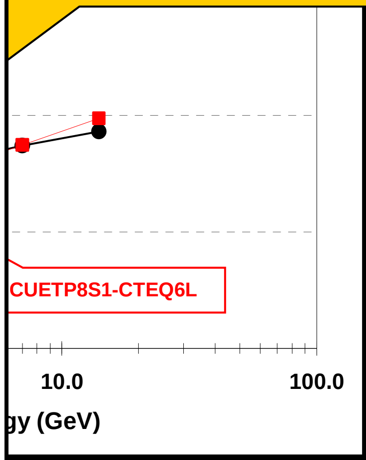
M. H. Seymour[a] A. Siódmok[a]

[a] *Consortium for Fundamental Physics, School of Physics and Astronomy, The University of Manchester, Manchester, M13 9PL, U.K.*

E-mail: michael.seymour@manchester.ac.uk, andrzej.siodmok@manchester.ac.uk

ABSTRACT: We review the modelling of multiple interactions in the event generator HERWIG++ and study implications of recent tuning efforts to Tevatron and LHC data. It is often said that measurements of the effective cross section for double-parton scattering, σ_{eff}, are in contradiction with models of the final state of multi-parton interactions, but we show that the HERWIG++ model is consistent with both and gives stable predictions for underlying event observables at 14 TeV.

HIA 8 predicts an dependence for σ_{eff}!



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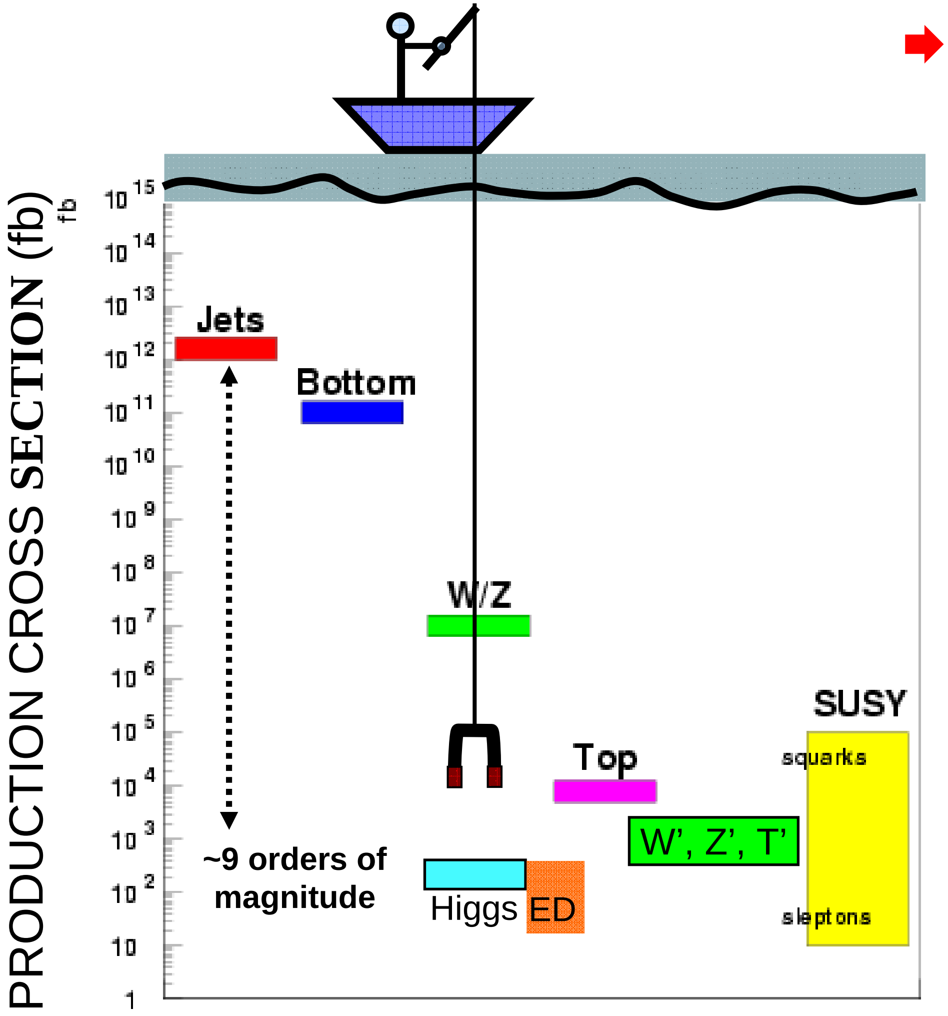
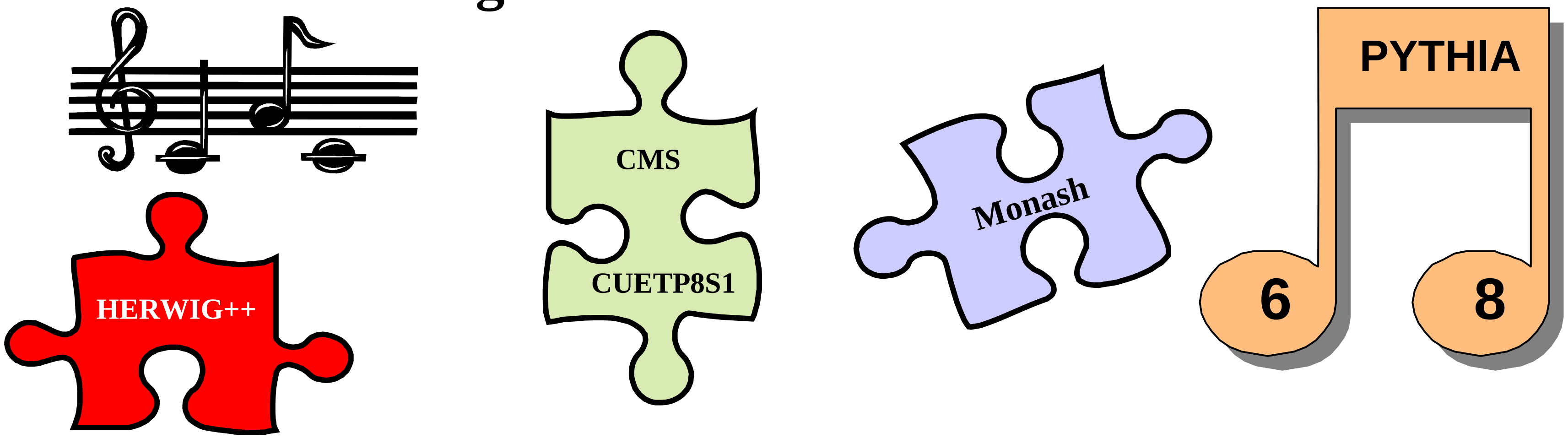


- The CDF & D0 continue to produce important precise QCD and electroweak measurements!

Summary: QCD MC Tunes

We now have at lot of MB & UE data at 300 GeV, 900 GeV, 1.96 TeV, and 7 TeV! We can study the energy dependence more precisely than ever before!

➡ **Several new and improved QCD MC tunes have already been constructed using data from the "Tevatron Energy Scan" and more will be coming soon!**



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We will be ready for the future LHC energies of 13 & 14 TeV!

- Sev y been construc n" and more wil